

1. A liquid crystal display device, comprising:
  - two substrates facing and spaced from each other, at least one of the substrates being transparent;
  - electrodes positioned to establish an electric field in the space between the two
  - 5 substrates;
  - one or more (polymerization initiating and enhancing) PIE elements located between the substrates;
  - one or more polymer elements located primarily in the vicinities of the PIE elements, the polymer elements located between the two substrates and having been polymerized in
  - 10 situ in response to the PIE material carried on or within the PIE elements; and
  - electrooptic material filling at least a portion of the space between the two substrates.
2. The liquid crystal display device of claim 1 wherein the polymer elements comprise polymer supports that extend between the two substrates.
- 15 3. The liquid crystal display device of claim 1 wherein the polymer elements comprise polymer members that do not extend between the two substrates..
4. The liquid crystal display device of claim 1 further comprising one or more spacer
- 20 elements in addition to the PIE elements.
5. The liquid crystal display device of claim 4 wherein the spacer elements do not serve a PIE function.
- 25 6. The liquid crystal display device of claim 4 wherein the spacer elements comprise a large number of generally spherical or cylindrical elements.
7. The liquid crystal display device of claim 6 wherein the spacer elements comprise glass.
- 30 8. The liquid crystal display device of claim 7 wherein the glass is etched.

9. The liquid crystal display device of claim 6 wherein the spacer elements comprise plastic.

10. The liquid crystal display device of claim 9 wherein the plastic is porous.

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11. The liquid crystal display device of claim 6 wherein the spacer elements comprise high-surface area particles that are nanoporous, mesoporous, or microporous

12. The liquid crystal display device of claim 6 wherein the spacer elements are  
10 randomly located in the space between the substrates.

13. The liquid crystal display device of claim 2 wherein the PIE elements comprise a large number of elements randomly across the space between the substrates.

14. The liquid crystal display device of claim 6 wherein the PIE elements comprise a  
15 large number of elements generally of smaller diameter than the spacer elements.

15. The liquid crystal display device of claim 14 wherein the PIE elements are generally not in contact with the substrates.

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16. The liquid crystal display device of claim 13 wherein the PIE elements are in contact with only one substrate.

17. The liquid crystal display device of claim 14 wherein the PIE elements are non-  
25 structural, in that they do not provide support for the substrates.

18. The liquid crystal display device of claim 14 wherein the average diameter of the PIE elements is 50% or less of the average diameter of the spacer elements.

19. The liquid crystal display device of claim 14 wherein the PIE elements comprise  
30 a lattice network structure.

20. The liquid crystal display device of claim 19 wherein the lattice network structure is two-dimensional.

5        21. The liquid crystal display device of claim 19 wherein the lattice network structure is three-dimensional.

22. The liquid crystal display device of claim 13 wherein the PIE elements are non-uniform in size and shape.

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23. The liquid crystal display device of claim 13 wherein the PIE elements have a rough surface.

24. The liquid crystal display device of claim 14 wherein the spacer elements and  
15        PIE elements are distributed generally randomly across the space between the substrates.

25. The liquid crystal display device of claim 24 wherein most of the PIE elements are free to move around in the spaces between the spacer elements prior to polymerization of the polymer supports.

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26. The liquid crystal display device of claim 24 wherein the porous membrane serves as both a spacer element and a PIE element, and wherein the polymer supports are formed in situ in the vicinity of the portions coated with or containing PIE material.

25        27. The liquid crystal display device of claim 26 wherein the porous membrane is an extensible porous membrane.

28. The liquid crystal display device of claim 14 wherein the PIE elements are located in non-image areas of the substrate.

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29. The liquid crystal display device of claim 28 wherein the PIE elements are located along the peripheries of the substrates and serve as one or more sealing members sealing the space between the substrates.

5           30. The liquid crystal display device of claim 28 wherein the PIE elements are located at interpixel regions.

31. The liquid crystal display device of claim 2 wherein the PIE elements comprise a prepolymer that contracts upon in situ polymerization.

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32. The liquid crystal display device of claims 2 or 4 wherein the majority of the polymer supports are bonded to each of the two substrates.

33. The liquid crystal display device of claims 2 or 4 wherein the polymer supports  
15 are primarily separate members not interconnected with one another.

34. The liquid crystal display device of claim 33 wherein one or more interconnecting regions of polymer interconnects a majority of the polymer supports.

20           35. The liquid crystal display device of claim 34 wherein one of the interconnecting regions comprises a layer of polymer adjacent one of the substrates.

36. The liquid crystal display device of claim 2 wherein the PIE material is applied to the PIE elements before introduction of the PIE elements to the space between the substrates.

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37. The liquid crystal display device of claim 2 wherein the PIE material is applied to the PIE elements after introduction of the PIE elements to the space between the substrates.

38. The liquid crystal display device of claim 2 wherein the PIE material is a coating  
30 applied to the PIE elements.

39. The liquid crystal display device of claim 2 wherein the PIE elements are dry sprayed on to the substrate before application of the electrooptic material.

40. The liquid crystal display device of claim 2 wherein the PIE elements are wet  
5 sprayed on to the substrate.

41. The liquid crystal display device of claim 40 wherein a solvent used for wet spraying comprises a PIE material or has a PIE material in solution or suspension.

10 42. The liquid crystal display device of claim 2 wherein the PIE material comprises one or both of the following: an initiator and an accelerant of the in situ polymerization process.

43. The liquid crystal display device of claim 42 wherein the PIE material is light  
15 activated.

44. The liquid crystal display device of claim 43 wherein the PIE material comprises a photoinitiator.

20 45. The liquid crystal display device of claim 44 wherein the photoinitiator comprises a plurality of photoinitiators of different spectral sensitivities, so that polymerization may be initiated at different times in different locations.

46. The liquid crystal display device of claims 43 or 44 wherein the light is  
25 ultraviolet light.

47. The liquid crystal display device of claim 42 wherein the PIE material is heat activated.

30 48. The liquid crystal display device of claim 42 wherein the PIE material is self activated after a period of time following assembly of the display.

49. The liquid crystal display device of claim 42 wherein the PIE material comprises both a photoinitiator and an accelerant.

5 50. The liquid crystal display device of claim 2 wherein the PIE elements are applied to the substrates by at least one of the following processes: pipette, silk screen, syringe.

51. The liquid crystal display device of claims 1 or 2 wherein the PIE elements are porous structures with a porous matrix, and the PIE material is absorbed into the porous  
10 matrix of the porous structures.

52. The liquid crystal display device of claim 51 wherein the porous structures are nanoporous ceramic or silica based materials.

15 53. The liquid crystal display device of claim 2 wherein the PIE elements are etched glass.

54. The liquid crystal display device of claim 51 wherein the PIE elements are porous plastic.  
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55. The liquid crystal display device of claim 51 wherein the PIE elements comprise an open network of polymer spheroids formed so that the electrooptic material fills inter-polymer regions.

25 56. The liquid crystal display device of claim 51 wherein the porosity of the porous structure is selected to yield a desired concentration of PIE material.

57. The liquid crystal display device of claim 51 wherein the polymer penetrates into the porous matrix sufficiently to improve adhesion with the PIE element.  
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58. The liquid crystal display device of claim 51 wherein at least some of the PIE elements serve as spacer elements.

59. The liquid crystal display device of claim 2 wherein the electrooptic material and a prepolymer are applied between the substrates as a mixture, and during in situ polymerization a phase separation of the electrooptic material and the polymer occurs.

60. The liquid crystal display device of claim 59 wherein the PIE elements are mixed into the mixture prior to application between the substrates.

61. The liquid crystal display device of claims 2 or 59 wherein the electrooptic material is a liquid crystal material.

62. The liquid crystal display device of claims 2 or 59 wherein the electrooptic material is a mesomorphic material.

63. The liquid crystal display device of claim 2 further comprising at least one electrode on at least one substrate to generate the electric field.

64. The liquid crystal display device of claim 63 further comprising at least one electrode on the second substrate.

65. The liquid crystal display device of claim 1 wherein the polymer used for in situ polymerization of the substrates comprises an acrylic based adhesive.

66. The liquid crystal display device of claim 1 wherein the polymer used for in situ polymerization of the substrates comprises an epoxy-based adhesive.

67. The liquid crystal display device of claim 1 wherein the polymer used for in situ polymerization of the substrates comprises a urethane-based adhesive.

68. The liquid crystal display device of claim 1 wherein the polymer used is primarily cured by light.

69. The liquid crystal display device of claim 1 wherein the polymer used is primarily cured by heat.

70. The liquid crystal display device of claim 1 wherein the polymer used is primarily cured via intermixing of a chemical additive.

71. The liquid crystal display device of claim 2 wherein the substrates comprise a flexible polymer material.

72. The liquid crystal display device of claim 71 wherein the display is capable of withstanding the flexing text referenced in the detailed description.